Effects of Different Irrigation Programs on Growth, Yield, and Fruit Quality of Drip-Irrigated Melon in Dardanelles (Çanakkale) Troia region

Murat Tekiner
1Canakkale Onsekiz Mart University, Agriculture Faculty, Department of Irrigation and Farm Structure, Turkey
mtekiner@yahoo.com

Canan Öztokat
Canakkale Onsekiz Mart University, Agriculture Faculty, Department of Horticulture, Turkey
cananoztokat@yahoo.com

İsmail Taş
Harran University Agriculture Faculty, Department of Irrigation and Farm Structure, Turkey
tas_ismail@yahoo.com

Abstract : This research was carried out under field conditions to determine the best proper irrigation interval and amount of irrigation water for pineapple type melon. Evaporations from class-A pan were taken into consideration to determine the amounts of irrigation water to be applied. Three different irrigation intervals (I_1= 4 days, I_2=8 days and I_3=12 days) and four different pan coefficients (Kcp1= 0.50, Kcp2= 1.00, Kcp3= 1.50, Kcp4= 2.00) were used to calculate the amounts of irrigation water. Total amounts of irrigation water varied between 168 – 871 mm and yields varied between 14.20-49.04 Mg.ha^{-1}. The highest yield was obtained from the largest irrigation interval with the lowest pan coefficient ($I_3K_{cp}1$).

Introduction

Province of Çanakkale is located over the Biga peninsula in northwest of Turkey. Total surface area of the province is 993 300 ha and 330 337 ha of this area is allocated for agricultural purposes and 111.047 ha (34%) of this agricultural lands is irrigable. However, 73 643 ha of irrigable portion is now under irrigation and 37 404 ha (33.7%) is used under dry conditions. Drip and sprinkler irrigation systems are used over 90% of irrigated lands (ÇTİM, 2010).

Melon (*Cucumis melo L.*) is an annual fruit with hairy body and superior aroma. Since it has summer and winter varieties, it is consumed all around the year. Turkey with proper climate conditions has a significant role in melon production (Sakaldaş et al. 2009). World melon production is 20 million tons and China meets 6.6 million tons (34.5%) of this world production and Turkey has the second place in production with 1.8 million ton (9.4%) (BATEM, 2010). Melon has the 4th place after tomato, pepper and watermelon among the vegetables produced in Çanakkale and total melon production of the year 2008 was 19 000 tons from 10 855 da land area (ÇTİM, 2010).

Irrigation at proper time with the proper amounts of water is a critical issue to provide optimum yield and quality in plant production. Srinivas et. al. (1989) indicated melon yields of 12-15 Mg.ha^{-1} under dry conditions and 25-30 Mg.ha^{-1} under irrigated conditions (Dogan et al. 2008). Sousa et. al. (1999) carried out drip irrigation research for melon over sandy soils of Brazil and applied irrigation intervals of 0.5, 1, 2, 3 and 4 days. Researchers observed that 0.5 and 1 day intervals yielded the highest marketable yields. In another study carried out in Iran, Alizadeh Khazai et al. (1999) used furrow and drip irrigation systems and 25, 50% water deficits for melon over silty soils. Researchers obtained the highest yield from drip irrigation with full irrigation (Yıldırım et al. 2009). Faberio et al. (2002) applied water deficits at flowering, fruit formation and ripening periods of melon and investigated impacts of water deficit on fruit yield and quality and observed that melon had the highest sensitivity against water deficit at fruit formation period. Barros et al. (2002) applied different amounts of irrigation water (233.8, 222.4, 204.4, 183.5, 158.9 ve 132.2 mm) and nitrogenous fertilizer (0, 75, 150 ve 300 $kg.ha^{-1}$) and received the highest yield with 222.4 mm irrigation water and 209.2 kg ha^{-1} application (Şengül 2009). Researchers also indicated that increased amounts of irrigation water instead of nitrogen fertilization didn't increase the yield. In another research, 6 different amount of irrigation water (0-25-50-75-100 and 125%) determined by using Class-A Pan evaporation data and applied by using surface and subsurface drip irrigation system was studied and the highest yield was obtained from 83% of pan coefficient for subsurface system and 92% of pan coefficient for surface system (Dogan et al. 2008). Cabello et al. (2009) studied the effects of different irrigations and nitrogen fertilization on melon yield and indicated that yield didn't decrease at 90% irrigation with 90 $kg.ha^{-1}$ nitrogen fertilization.

As it was seen all above literature and researches, irrigation interval and amounts of irrigation water are significant issue for melon yield and quality. In this study, proper irrigation interval and amount of irrigation water providing the optimum yield and quality were tried to be determined for pineapple type (Carna F1) melon. This variety is preferred among the producers of the region.

Materials and Methods

Field experiments were carried out over the fields of a farmer in Çıplak village at Troia Region of central town of Canakkale Province. Research field is located at 39° 57' north latitudes and 26° 16' east longitudes. Pineapple type Carna F1 variety melon was used as the material of the study. Climate of the region is Mediterranean and Black Sea transition climate. According to long-term averages of the nearest meteorological station, annual average temperature of the region is 14.9°C, average total precipitation is 599 mm, average relative humidity is 76%, average wind speed is 3.9 $m.s^{-1}$ (Anonymous, 2005). Climate data for the year 2009 were presented in Table 1.

Mounts	1	2	3	4	5	6	7	8	9	10	11	12
Wind Speed (m/s)	5.0	5.5	3.9	3.7	3.1	3.1	3.5	4.6	3.8	3.6	2.6	5.8
Relative Humidity (%)	83.2	78.0	78.0	76.1	61.8	64.4	58.5	62.8	71.5	81.6	81.7	72.0
Temperature (°C)	7.8	7.2	8.8	12.2	18.4	22.7	26.4	25.3	20.6	17.6	12.5	11.0
Precipitation (mm)	175.2	169.2	119.8	22.6	10.8	11.4	0.0	0.0	88.2	39.2	65.8	237.1

Source: Turkish State Meteorological Service

Table 1. Data of Canakkale Meteorological station for the year 2009

Soils of experimental fields have medium texture with 23.2% field capacity, 13.5% permanent wilting point and 1.35 $g.cm^{-3}$ unit weight. Ground water table and impervious barrier were not observed within or around the plots; there were not any drainage problems over the experimental fields. Topography was smooth or close to smooth with maximum 2% slope. Readily available pressurized pipe system was used to receive water and drip irrigation system was applied for irrigations.

Three different irrigation intervals (I_1= 4 days, I_2= 8 days and I_3= 12 days) and four different pan coefficients ($K_{cp}1$= 0.50, $K_{cp}2$= 1.00, $K_{cp}3$= 1.50, $K_{cp}4$= 2.00) were used as the treatments of the study.

All the treatments were irrigated at amounts calculated by the equation given in Doorenbos and Pruitt (1992) until the date of harvest.

$$I = Epan.A.Kcp.P$$

where I irrigation water amounts (mm), Epan evaporation from a standard class A pan (mm), A plot area (m^2), Kcp crop pan coefficients (0.50, 1.00, 1.50, 2.00), and P crop coverage (%).

Evapotranspiration (ET) was calculated in accordance with Allen et al. (1998);

$$ET = I + P \pm \Delta s$$

where P is precipitation (mm) and Δs is the change in soil profile water content (mm).

Experiments were performed in splitted randomized block design with 3 replications. Seed were planted at 1.20 x 0.60 spacing (row spacing x inner row seed spacing) on 29th of May 2009. There were 4 rows in each plot and 6 plants on each row; therefore there were a total of 24 plants in each plot. A row from each side and top and bottom plants of each row were separated for side effect and 8 plants were observed in each plot. Two hoeing and fungicide applications were performed during the growing period. Fertilization was performed before the plantation with 10 kg.da^{-1} NH_4NO_3, 25 kg.da^{-1} super phosphate and 12 kg.da^{-1} potassium sulphate. Remaining nitrogenous fertilizer was applied as urea and ammonium sulphate at the rate of 8 kg.da^{-1}. Three harvests were performed on 20th of August, 25th of August and 2nd of September.

Yield (Mg.ha^{-1}), single fruit weight (g), fruit width (mm), fruit length (mm), length of seed cavity (mm), flesh thickness (mm), flesh firmness (kg.cm^{-2}), amount of water-soluble dry matter (Brix) (%) and taste analysis were carried out to determine the yield and quality parameters. For flesh firmness determination, 1cm^2 area of 3 different point from each fruit for the penetration force measurements were individually recorded using a 5/16 (8 mm) diameter probe on a penetrometer (Bishop, Italy). TSS concentration was determined in each fruit with a digital refractometer Atago PAL-1 (Atago Co. Ltd., Japan) at 20°C. Fruit taste was graded by 10 experienced panelists using a 1 to 5 scale (1: very bad, 2: bad, 3: acceptable, 4: good, 5: very good) for each replicate.

Data were subjected to ANOVA test for statistical analysis and "Minitab 15" statistical software was used for statistical analysis. Differences among the averages were tested according to LSD test at P=0.05 significance levels.

Results and Conclusions

The best irrigation program was tried to be determined for Carna F1 melon cultivar over the farmer fields during the year 2009. The variety was found to be highly resistant to drought and fruits were large. Statistical analyses for yield and quality parameters were carried out and results were given in Table 2.

Treatment		Irrigation amounts (mm)	ET (mm)	Yield (Mg.ha^{-1})	Mean fruit weight (g)	Width (mm)	Length (mm)	Length of Seed House (mm)	Flesh Thickness (mm)	Flesh Firmness (kg.cm^{-2})	°Brix	Taste
I_1	**Kcp 1**	182	336.5	20.65^{e}	3166^{bcd}	528	634^{bcd}	500^{b}	631^{a}	0.623^{d}	11.60^{de}	2.7^{a}
	Kcp 2	388	673.0	21.55^{e}	2519^{g}	478	569^{e}	422^{f}	549^{h}	0.643^{cd}	11.83^{cde}	4.3^{ab}
	Kcp 3	622	1009.5	17.66^{f}	2978^{def}	534	662^{abc}	445^{def}	615^{ab}	0.567^{de}	13.62^{a}	3.5^{d}
	Kcp 4	856	1346.0	16.72^{f}	3406^{bc}	533	644^{bcd}	486^{bc}	605^{bcd}	0.589^{d}	11.66^{de}	2.7^{e}
I_2	**Kcp 1**	176	327.5	34.35^{b}	3444^{b}	525	670^{abc}	498^{b}	587^{def}	0.582^{d}	11.68^{de}	4.3^{ab}
	Kcp 2	380	655.0	29.65^{c}	2776^{efg}	493	617^{d}	453de	558^{gh}	0.604^{d}	12.66^{bc}	4.7^{a}
	Kcp 3	611	982.5	24.04^{d}	3045^{cde}	519	641^{bcd}	470^{cd}	591^{ede}	0.698^{bcd}	12.33^{bcd}	3.9^{bcd}
	Kcp 4	871	1310.0	**14.20**^{g}	3423^{b}	524	677^{ab}	537^{a}	566^{fgh}	0.786^{bc}	12.65^{bc}	4.2^{abc}
I_3	**Kcp 1**	168	303.5	**69.04**^{a}	3851^{a}	540	692^{a}	499^{b}	609^{bc}	0.431^{e}	11.43^{e}	3.6^{cd}

	Kcp 2	370	607.0	28.96^{c}	2970^{def}	496	635^{bcd}	452^{de}	562^{gh}	0.788^{bc}	12.57^{bc}	4.3^{ab}
	Kcp 3	603	910.5	26.28^{d}	2629^{fg}	494	605^{de}	430^{ef}	572^{efg}	0.814^{b}	12.32^{bcd}	4.7^{a}
	Kcp 4	869	1214.0	15.66^{fg}	3283^{bcd}	508	631^{cd}	437^{ef}	593^{bcde}	0.999^{a}	13.00^{ab}	4.3^{ab}
LSD (0.05)*				2.297	361.8	NS	43.75	26.12	22.05	0.1499	0.833	0.6003

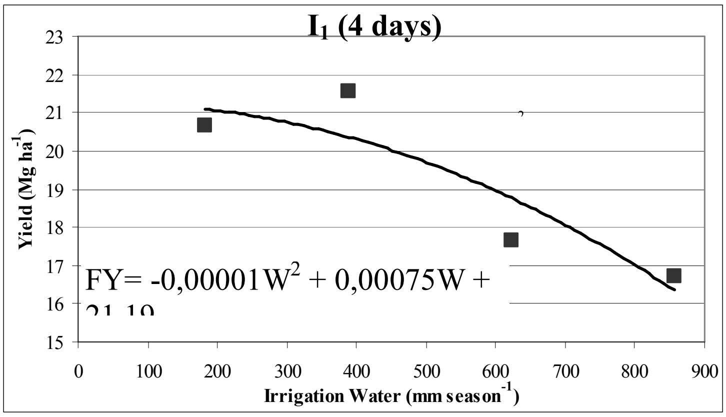
* LSD (0.05) irrigation interval x pan coefficient (IxKcp)

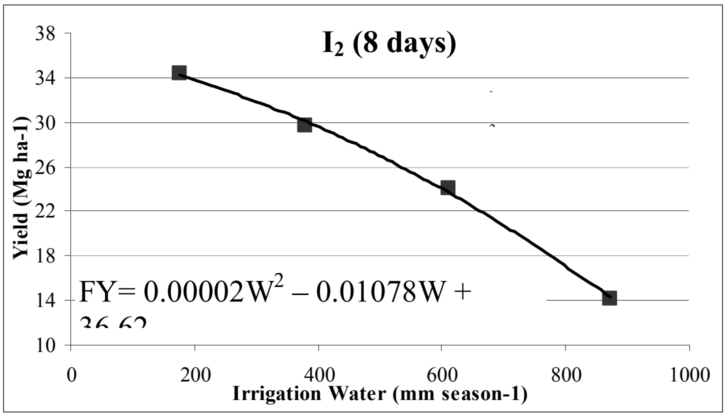
Table 2. Statistical analysis results for yield and quality parameters

Yield per hectare was found to be significant at $p<0.05$ level and the highest yield was obtained from the treatment I_3-Kcp1 with 49.04 Mg.ha^{-1} and the lowest was observed in I_2-Kcp4 treatment with 14.20 Mg.ha^{-1}. Irrigation intervals and pan coefficients were found to be significant among themselves at $p<0.05$ level, the best irrigation interval was determined as I_3 (12 days) with pan coefficient of Kcp1 (0.5). On the contrary to other melon varieties, yield increases in Carna F1 variety with increased irrigation interval and reduced amount of irrigation water. This can be seen clearly from water-yield relation graphs in Figure 1.

With regard to regression analysis, the highest water-yield relationship was observed in I3 treatment with 12 days irrigation interval ($R^2=0.99$). Şalk et.al. (2008) stated that some Thracian farmers were making melon production under dry conditions without any irrigation and they had well yields.

With regard to single fruit weight, IxKcp interaction was found to be significant and as it was in the yield per hectare I_3-Kcp1 treatment had the highest fruit weight with 3851 g. Fruit weight of I_2-Kcp4 was also high (3423 g) but the yield of this treatment was low since fruit per plant was low in this treatment. The lowest fruit weight was observed in I_1-Kcp2 treatment with 2519 g. With regard to fruit width, interaction of treatments was not found to be significant but pan coefficients were found to be significant. The lowest fruit width was observed in Kcp2 treatment. Treatment I_3-Kcp1 was in front of the group with regard to fruit length (692mm). Pew and Gardner (1983) mentioned about lower size fruit production of local producers with irrigation practices (Şengül, 2009). The highest seed house size was observed in I_2-Kcp4 treatment (537 mm), the lowest was observed in I_1-Kcp2 treatment (422 mm). With regard to flesh thickness, the highest value was observed in I_2-Kcp4 treatment (692 mm) and the lowest in I_1-Kcp2 treatment (549 mm) and IxKcp interaction was found to be significant for both parameters at $p<0.05$ levels.





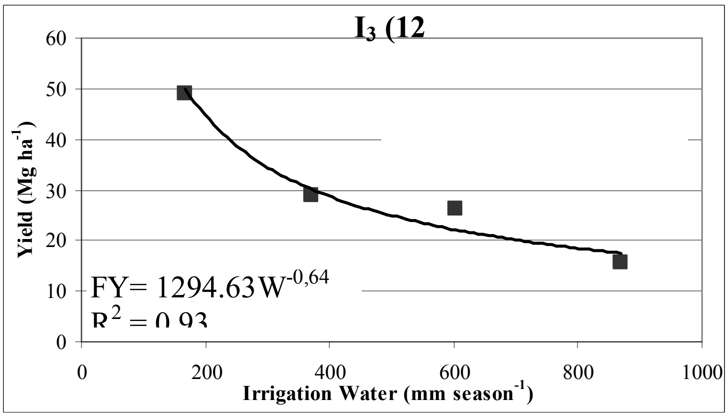


Fig. 1. Relationship between seasonal applied irrigation water (W) and plant fruit yield (FY) for irrigation interval

Flesh firmness is among the most significant parameters determining fruit quality and post-harvest physiology. The highest flesh firmness value was observed in I_1-Kcp2 treatment with 0.99 kg.cm^{-2} and lowest in I_3-Kcp1 treatment with 0.43 kg.cm^{-2}. Flesh firmness increased with increased irrigation interval and pan coefficient. Sakaldaş et.al. (2009) stated longer shelf lives for pineapple type melons with higher flesh firmness. Water-soluble dry matter amounts were also found to be significant ($p<0.05$) like flesh firmness and increased with increasing irrigation interval. The treatment I_1-Kcp3 has the highest value with 13.62% and I_3-Kcp1 had the lowest with 11.43%.

Brix is one of the easiest way to determine the harvest time and this value can reach to 13-17% under high temperatures (Şalk et.al. 2008). Faberio et al. (2002) indicated that water deficit applied at flowering period might negatively affect the fruit quality but increase the rate of sugar in fruits. The lowest Brix value was observed in I_3-Kcp1 treatment and the lowest flesh firmness was also observed in this treatment. The taste value of the same group was 3.6 (above average). In other words, although the aforesaid treatment had lower Brix and flesh firmness values than the other treatments, it had allowable shelf life and taste value. Results of taste evaluations were found to be significant ($p<0.05$) and lowest value was observed in I_1-Kcp1 and I_1-Kcp4 treatments with 2.7.

Based on the results obtained from this study, I_3-Kcp2 treatment was found to be the best alternative for regional producers with regard to yield and quality. However, in case of possible water deficiencies in the future, I_3-Kcp1 or I_2-Kcp2 treatments may be selected. Further researches can be carried out for the same melon variety with pan coefficients ranging between 0.0 -1.00 and irrigation intervals between 8-12 days and outcomes of these researches should be delivered to local producers. On the other hand bigger melon fruits have some disadvantages in terms of marketing demands but fruits obtained from best irrigation treatment can be used in the point of its harmony according to the changing needs in terms of different consuming types like fresh cut etc.

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